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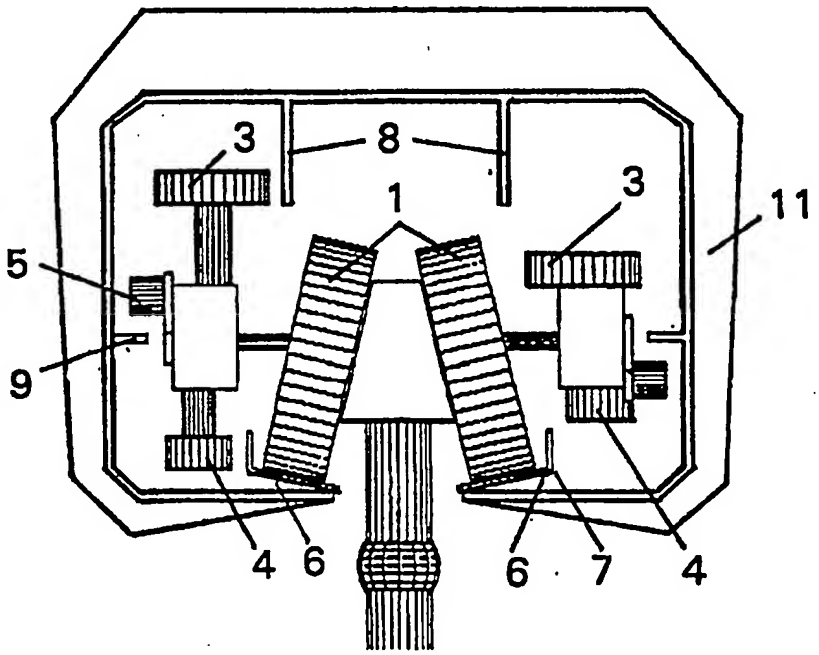
(57) Abstract

Overhead railway system comprising an elevated track and switches (19) placed above the carriage and carriages (13) suspended from the track by means of a truck (12). The truck (12) has at least two successive pairs of wheels (1). The wheels (1) in the pairs of wheels are inclined or have a conical shape at their circumference, and the rails (6) are inclined to an angle corresponding to the inclination or conicity of the wheels so that, when the truck turns, the forces resulting from the weight of the carriage (13) and truck (12) and from the force applied to the upper guide (3) are transmitted to the rail from the wheels in contact with the rail (6) in a direction substantially perpendicular to the surface of the rail (6). Both when the truck runs straight ahead and when it turns at a switch, between the truck (12) and the track there are two and only two supporting lines continuing unbroken across the switch.



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OVERHEAD RAIL SYSTEM.

The present invention relates to an overhead railway system as defined in the preamble of claim 1.

The overhead railway has not been established as a means of passenger transport although it has many indisputable advantages. On the other hand, in automatic material transport the situation is exactly the opposite. A transport system can be rendered considerably safer if its unmanned transport unit travels in the air. However, with current solutions, it has not been possible in overhead railway systems, either, to guarantee a safety level sufficient to cause corresponding systems to be widely applied in passenger transport as well. Yet it would be possible, using automatic control, to optimize the travel of the transport units so as to save time and energy. If a service level as flexible as possible is to be guaranteed without high labour costs, unmanned transport units should be introduced.

The most difficult point in the overhead railway is the switch. In railway and tramway traffic, most of the accidents other than collisions are caused by switches. In the case of an overhead railway, the consequences may be considerably more serious. Railway safety systems require that, in all circumstances, a train approaching a switch should be able to stop if a malfunction occurs in the switch and the switch does not turn in accordance with the control command issued. Consequently, when the highest speeds are used, the intervals between successive trains must be several kilometres long. Under these conditions, urban traffic can never become dense and flexible if implemented using overhead tracks.

US patent specification 3830163 presents an overhead railway switch solution in which the turning of the train is controlled by a motor placed in the switch and turning strips placed inside the rail frame. The strips are hit by levers

in the truck which control the position of sixteen guide wheels movable along a vertical axis. The truck presented in this specification has a very complex structure. In addition, such a truck can easily break down in use or damage rail switches. In said specification, the frame structure of the track and switch is provided with three flanges and the truck has guide wheels which follow the flanges on either side. These constitute as many as eight (rigid) points of support. Taking the four points of contact between the main wheels and the rails into account, you have four additional supporting points. As is known, a body is sufficiently supported by three supporting points, so the extra supporting points cause continuous torsional forces in the truck moving along the track. Furthermore, the guide wheels above the track form a long line which is inflexible in the transverse direction. When the flange between them has a curved shape as in the region of a switch or a curvature in the track, the guide wheels tend to straighten this curvature. If this problem is to be met by providing a sufficient play, the result will be that the truck pitches continually sideways as there is nothing to stabilize its travel along the centre line. Neither can the truck presented in said specification cross an intersecting track because it has only two pairs of load-bearing wheels.

The object of the present invention is to eliminate the drawbacks of known technology and to achieve a system that is simpler and safer than previously known overhead railway systems. The features characteristic of the overhead railway system of the invention are presented in the attached claims.

In the present invention, there are no movable parts in the track or in the switch, and consequently the switch can never be in the wrong position or changing direction when a train reaches it. The turning direction is determined by the position of guides provided in the truck. The invention also comprises a safety mechanism which, in case of malfunction, prevents any attempts to change direction while crossing a

switch and ensures that the guides are in the correct position in case of malfunction when a train crosses a switch from the direction of a branch (in the direction in which the rails unite). When provided with four pairs of wheels, the truck of the invention also permits intersections of tracks at any angle.

Moreover, in the present invention there are always only two supporting lines which receive the forces resulting from the mass of the truck and carriage. No forces causing extra strain are present. Inclined wheels travelling on inclined rails stabilize the travel of the truck on the centre line.

In the following, the invention is described in detail by the aid of an example by referring to the attached drawings, in which

Fig. 1 presents the truck of the invention in end view.

Fig. 2 presents the truck of the invention in side view.

Fig. 3 presents the truck of the invention and the track frame.

Fig. 4 presents the truck of the invention at a switch.

Fig. 5 presents the forces acting on the truck when turning left at a switch.

Fig. 6 presents the track structure.

Fig. 7 presents an overhead track and a carriage travelling on it.

The invention relates to an overhead railway system which comprises a track (track frame 11, fig. 7) suspended in the air and provided with the switches needed for branching and carriages 13 suspended on the track by means trucks 12.

The truck 12 presented in fig. 1 and 2 has four successive pairs of wheels rigidly suspended and running on rails 6 placed at a short distance from each other. Having four pairs of wheels, the truck is able to cross the gaps occurring at the intersections of tracks. The wheels are so inclined that the upper edges of the wheels in a pair of wheels lie closer to each other than the lower edges. There are two reasons for this. For one, the truck 12 is thus guided to run along the midline of the track, and secondly, such inclination of the wheels is necessary to ensure that, when the truck runs across a switch, the force resulting from the weight of the carriage is applied to the rail 6 of the track in the plane of rotation of the wheel 1. Of the four pairs of wheels, two are driving pairs, and these are linked via a power transmission system (not shown) to a drive motor 2 placed under them.

On both sides of the truck there are upper and lower guides 3 and 4 which guide the truck as it travels across a switch. The guides rotate about their vertical shafts 14, 15. In addition, moved by an electromechanical actuator 16, they can move in the direction of their shaft, and they are so interlinked that when the upper guide 3 moves down, the lower guide 4 moves up, and vice versa. Thus, the guides on the same side of the truck are either in an outer position (upper guide 3 up, lower guide 4 down) or in an inner position (upper guide 3 down, lower guide 4 up). In addition, the guides 3,4 on opposite sides are mechanically so interlinked that when the guides on the left-hand side are in the outer position, those on the right are in the inner position, and vice versa. The carriage is suspended on a truck suspension element 17 passing between the rails 6, with air springs 10 supporting the carriage.

Fig. 3 shows the wheels 1, upper and lower guides 3,4 and lateral safety devices 5. The lateral safety devices 5 follow the motion of the upper guides 3, in other words, when the upper guide 3 is in its high position, the lateral

safety device 5 is also in its high position. The function of the lateral safety devices 5 is to ensure that - even in the case of a control failure - the position of the guides will not change while the train is crossing a switch and to ensure that, when the train is approaching a switch from a branch, the guides on the outer side with respect to the switch are in the outer position and, if necessary, to force them out. The motion of the lateral safety devices 5 is controlled by horizontal side flanges 9 provided at the middle of the side walls of the track frame 11 surrounding the truck. The wheels 1 run on rails 6 placed in the lower part of the track frame 11 and inclined to an angle corresponding to the inclination of the wheels 1. The outer edges of the rails 6 are provided with flanges 7 to limit the lateral movement of the wheels 1. When the train is passing over a curved portion of the track, the rail flange 7 limits the lateral motion from one side as the lower guide 4 hits the flange 7. In the upper part of the track frame 11 there are vertical guide flanges 8 for the upper guides 3 of both sides, placed on either side of the midline. The vertical guide flanges 8 are needed at a switch to provide a second support surface in addition to a rail 6 as explained below. Guide flanges 8 and side flanges 9 are only needed in the region of a switch.

In fig. 4, the truck 12 has just reached a switch but is still on its united portion and is beginning to turn left. In fig. 3, the guide flanges 8 lie closer to each other so that the upper guides 3 cannot touch the flange. As the truck approaches the fork of the switch, the positions of the guide flanges 8 shift out so much that in fig. 4 the left-hand guide flange 8 pries the truck 12 so as to lift the wheels off the right-hand rail 6. From this point on, the truck 12 is supported by the left-hand rail 6 and the left-hand guide flange 8 as it moves across the fork of the switch. The inclination of the wheels 1 is so chosen that, when the truck turns, the force generated by the mass of the carriage 13 and truck 12 is applied to the rail 6 in the

direction of the plane of rotation of the wheels 1 (fig. 5). Because of the forces thus applied to them, the wheels 1 are caused to run about straight. If the train is to run straight ahead across the switch, it can pass through it without the rail flange 7 being touched by the wheels 1 from the inside or by the lower guide 4 from the outside. On the other hand, when the train is turning, the lower guide 4 has to pry the wheels 1, which tend to run straight over the curved portion, so as to make them run in the direction of the rail 6.

Thus, the wheels of the truck run across the switch along two continuous supporting surfaces. The fact that there are expressly two supporting surfaces is of great importance. If there are more than two supporting surfaces, the load will continually vary between the various supporting surfaces, thus generating harmful torsional forces.

From the fact that the supporting surfaces are continuous it follows that there is no limitation as to the degree of curvature of the branching rails in the region of the switch. Therefore, a curvature beginning with a low gradient enables a train to run through the switch at full speed, in both directions.

After the switch, the left-hand branch has only a left-hand guide flange 8 while the right-hand branch has only a right-hand guide flange 8. The positions of these flanges shift gradually towards the midline. Farther away from the switch, no guide flanges 8 are needed at all.

Fig. 5 presents the forces acting on the truck when it is turning left at a switch. The geometry of the truck 12 determines the angle of inclination of the wheels. The sum of both the component forces F_{x1}, F_{x2}, F_{y1}, F_{y2} and the torques τ_1, τ_2 with respect to the supporting point of the wheels has to be zero. In the figure, f_1 is a component of force F_1 perpendicular to the lever l_1 between the centres

of the points of contact between the upper guide 3 and the guide flange 8 and between the wheel 1 and the rail 6 and, correspondingly, f_2 is a component of F_2 perpendicular to the lever l_2 between the centres of the point of contact between the wheel 1 and the rail 6 and of the joint 18. The sphere 18 at the end of the lower moment lever is a joint, to which the weight of the carriage is applied. The effect of the truck's own weight is not shown in the figure. The resultant of forces F_1 and F_2 is R. The forces and torques must satisfy the following equations:

$$F_{x1} + F_{x2} = 0$$
$$F_{y1} + F_{y2} = 0$$
$$\tau_1 + \tau_2 = 0.$$

When the truck approaches a switch from the direction of either branch, the guides 3,4 on the outer side with respect to the switch must be in their outer position. However, if they are in the wrong position due to a control failure, the lateral safety devices 5 will pry them out by force. As shown in fig. 6, the ends of the side flanges 9 in the branches of the switch 19 are provided with ramps 20 starting from a low level. If the electromechanical actuator 16 controlling the guides 3,4 has driven the guides on the outer side into the inner position, the lateral safety device 5 on that side is also in the low position. As the lateral safety devices 5 hit the ramp 20, they are turned up and at the same time the guides 3,4 on that side are driven out with a power exceeding the power of the actuator 16. When the switch is approached from its united side, there are no ramps 20 but the side flanges 9 start from the mid-level. Fig. 7 presents a truck 12 which has reached a switch with its guides 3,4 in the correct positions.

The contact surface of the wheels 1 can be coated with a friction-increasing, noise-damping material. As the direction of the forces transmitted from the wheels to the track mostly coincides with the plane of rotation of the wheels,

in other words, as there is but little side thrust, the coating of the wheels will endure and remain in position. Moreover, the contact surface can be made sufficiently wide with a view to the durability of the coating.

The inclination of the wheels can be substituted by using wheels suspended on horizontal shafts and by forming the circumference of the wheel into a conical shape corresponding to the inclination of the track. However, the conical shape has to be modified by adding a slightly barrel-shaped curvature to it so as to reduce the contact area between the track and the wheel. Otherwise the wheel will undergo wear because its inner edge, having a larger diameter, travels through a longer distance than its outer edge (with respect to the midline of the track).

It is obvious to a person skilled in the art that different embodiments of the invention are not restricted to the example described above, but that they may instead be varied within the scope of the claims presented below.

CLAIMS

1. Overhead railway system comprising an elevated track and switches (19) located above the carriage and carriages (13) suspended from the track by means of a truck (12),

said track having a pair of parallel rails (6) with a gap between them for the suspension of the carriage (13) and, at least in the region of a switch, vertical guide flanges (8) in the upper part of the track frame (11),

said truck (12) having at least two successive pairs of wheels (1), upper guides (3) placed on the sides of the truck and determining the turning of the carriage (13) at a switch (19) by leaning against the guide flanges (8), and lower guides (4) likewise placed on the sides of the truck, of which lower guides, when the truck turns, those lying on the side corresponding to the turning direction prevent the wheels (1) from moving too far towards the gap between the rails (6), and

in which the wheels (1) of the pairs of wheels are inclined or have a conical shape at their circumference, and the rails (6) are inclined in accordance with the inclination or conicity of the wheels so that, when the truck turns, the forces resulting from the weight of the carriage (13) and truck (12) and from the force applied to the upper guide (3) are transmitted to the rail from the wheels in contact with the rail (6) in a direction substantially perpendicular to the surface of the rail (6),

characterized in that

both when the truck runs straight ahead and when it turns at a switch, between the truck (12) and the track there are two and only two supporting lines continuing unbroken across the switch, which supporting lines, when the truck is travelling outside the switch, are the lines connecting the points of

contact between the rail (6) and the wheels (1) on each rail separately, and when the truck is travelling on a switch, the supporting lines are the line connecting the points of contact between the rail (6) and the wheels (1) on the side corresponding to the turning direction and the line connecting the points of contact between the guide flange (8) and the upper guides (3) on the side corresponding to the turning direction.

2. Overhead railway system according to claim 1, in which the upper and lower guides (3,4) are located on the sides of the truck (12), characterized in that the guides (3,4) are moved vertically by means of an actuating mechanism (16) and that they are so interlinked that, when the upper guide (3) moves in a vertical direction, the lower guide (4) moves simultaneously in the opposite direction.

3. Overhead railway system according to claim 1, characterized in that the guides (3,4) on opposite sides of the truck (12) are so interlinked that, when the guides on one side move in a vertical direction, the guides on the other side move simultaneously in the opposite direction.

4. Overhead railway system according to claim 1, characterized in that the truck (12) is provided with lateral safety devices (5) designed to ensure that the position of the guides will not change while the truck is crossing a switch and to ensure that, when the truck is approaching a switch from a branch, the guides on the outer side relative to the switch are in their outer position, and which lateral safety devices (5) follow the motion of the guides so that when the upper guide (3) is in its high position, the lateral safety device on the same side is also in its high position, the movement of the lateral safety devices (5) being controlled in the track frame (11) by horizontal side flanges (9) provided on its side walls.

5. Overhead railway system according to claim 1, characterized in that the truck has at least four pairs of wheels, enabling the truck to travel across intersecting tracks.

6. Overhead railway system according to claim 1, characterized in that, when the truck is turning, the lower guides (4) move towards flanges (7) fitted on the outer edges of the rails (6) so that, by hitting said flange (7), the lower guide (4) prevents the wheels from moving too far towards the gap between the rails (6).

7. Overhead railway system according to claim 1, characterized in that, when the truck is starting to cross a switch, the upper guides (3) on the side corresponding to the turning direction hit the corresponding guide flange (8) in the upper part of the track frame (11), the position of said guide flange (8) being shifted farther away from the midline of the track frame (11) before the actual fork of the switch, which guide flange (8) pries the wheels of the truck by means of the upper guide (3) so that the wheels on the outer side relative to the turning direction are lifted off the corresponding rail (6) and the truck (12) remains supported by the wheels (1) and upper guide (3) on the side corresponding to the turning direction until, after the fork of the switch has been passed, the position of said guide flange (8) is shifted back towards the midline, whereupon the wheels lifted off the rail (6) are lowered back onto the rail (6).

8. Overhead railway system according to claim 1, characterized in that, when the switch is approached from the direction of one of its branches, there is a ramp (20) in each branch in conjunction with the side flange (9) on the outer side with respect to the switch, each of which ramps (20) starts from the lower edge of the side of the track frame (11) and, if the lateral safety device (5) is in its low position, forces it up with a power exceeding the

actuating power of the actuating mechanism (16) normally controlling the position of the upper and lower guides (3,4), the forcing up of which lateral safety device (5) ensures that the upper guides (3) on the outer side with respect to the switch are in their high position and that the truck (12) always travels supported by the continuous outer rail and upper guide flange when it crosses a switch from this direction.

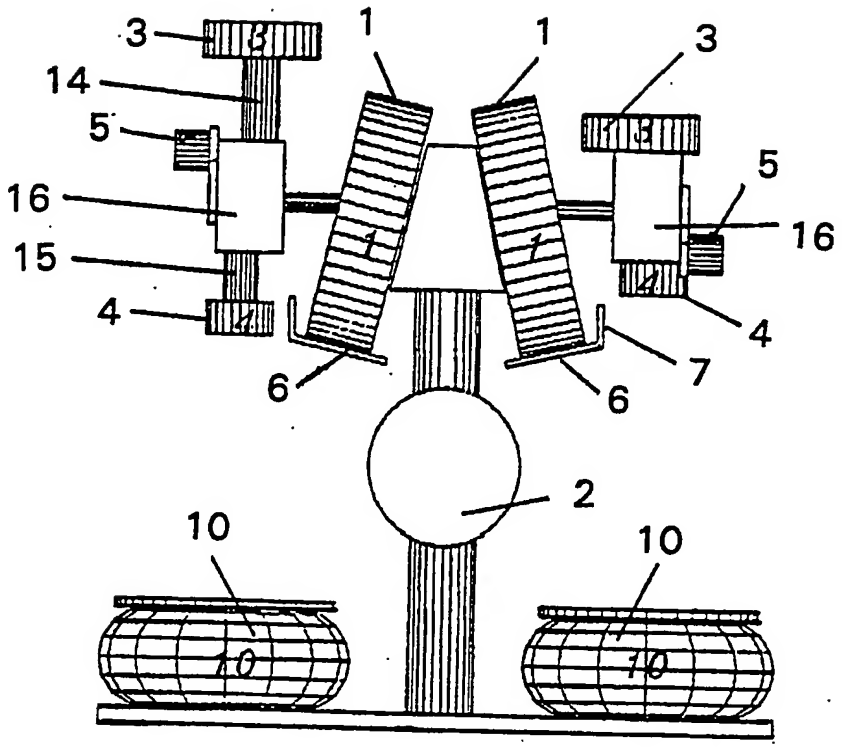

FIG. 1

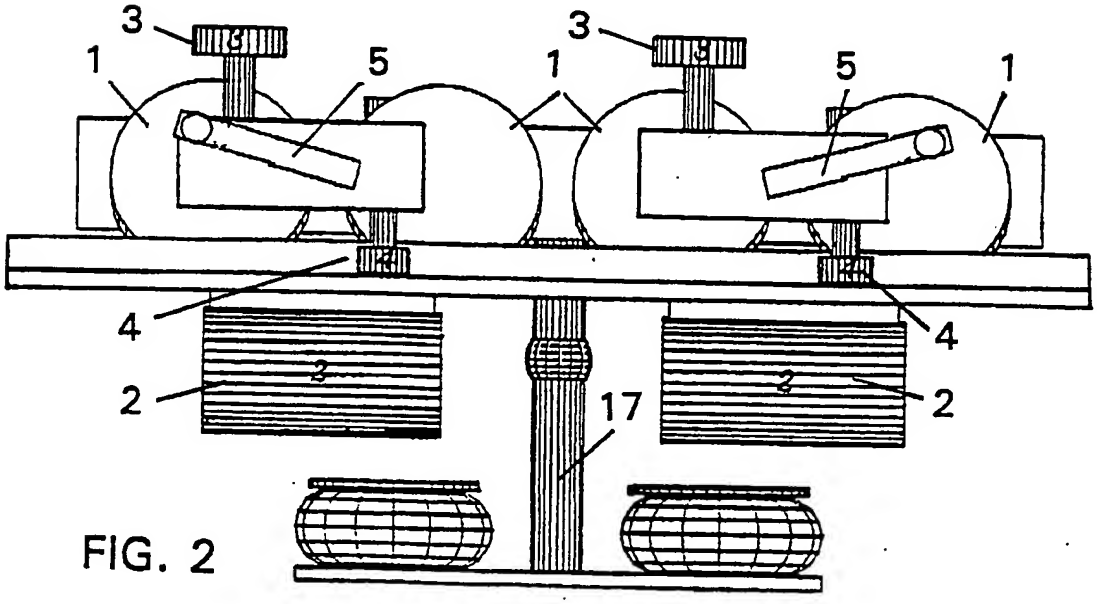

FIG. 2

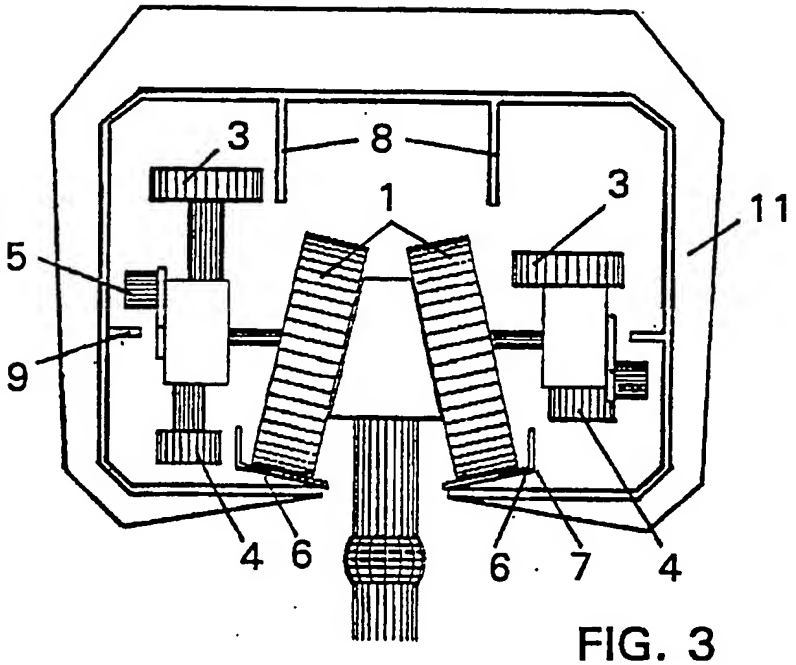

FIG. 3

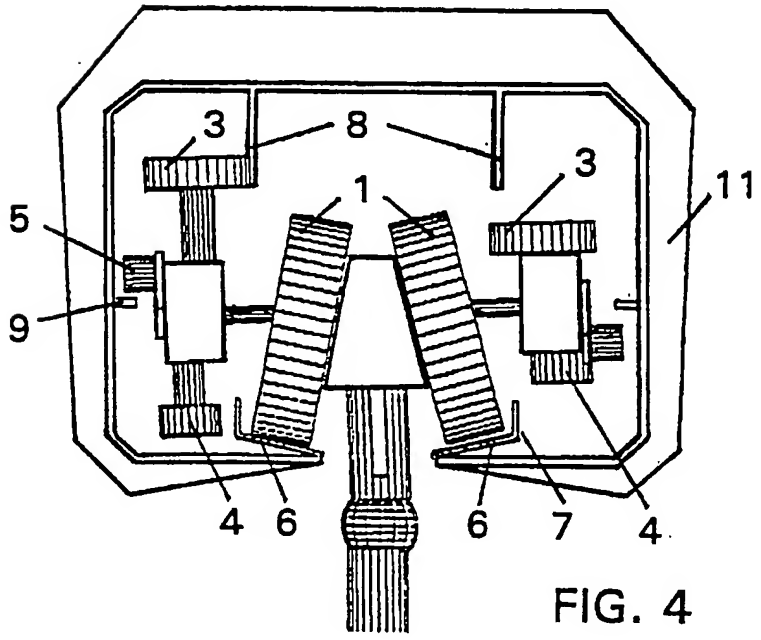

FIG. 4

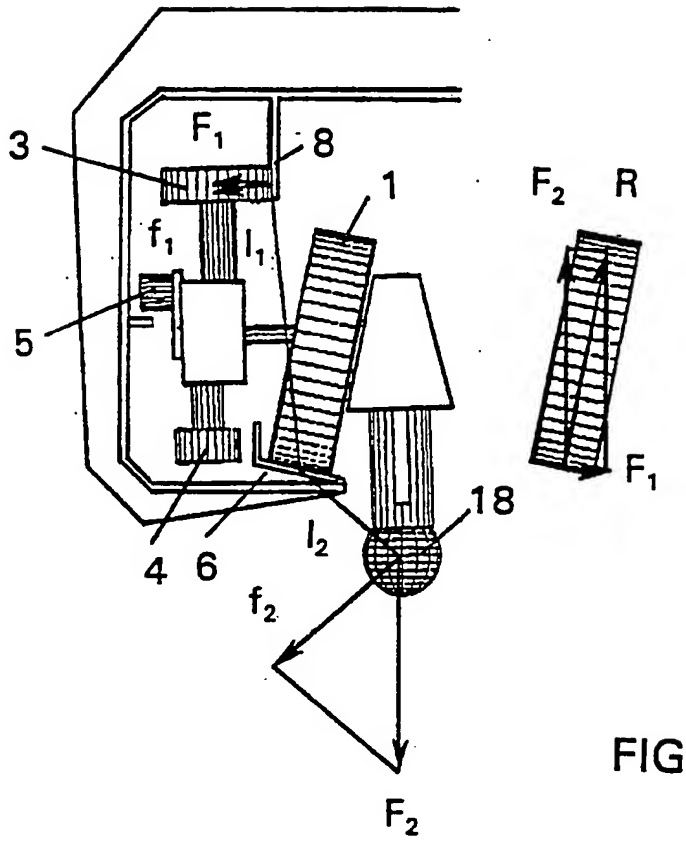

FIG. 5

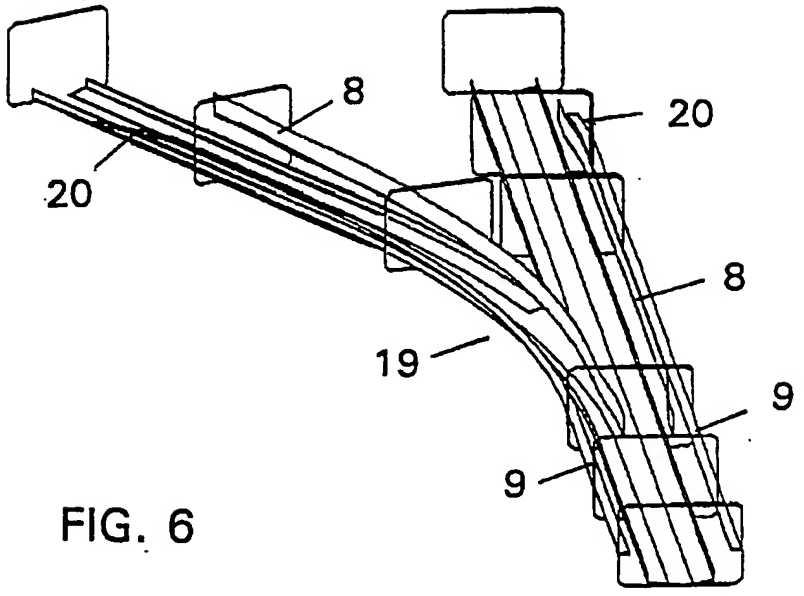

FIG. 6

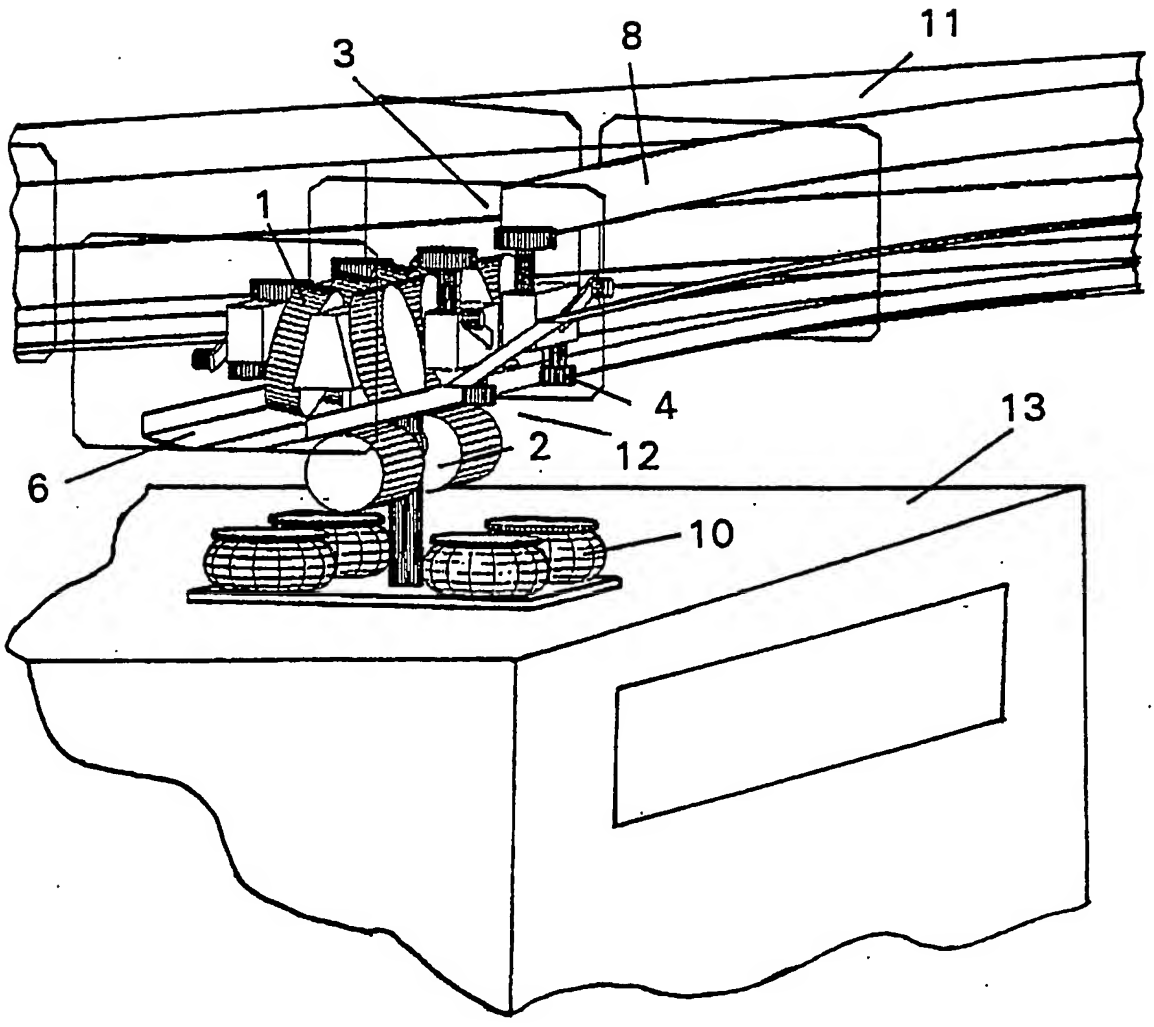

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 95/00043

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: E01B 25/26, B61B 3/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: E01B, B61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	SE, B, 470425 (J.-E. NOWACKI), 21 February 1994 (21.02.94) --	1-8
A	US, A, 3830163 (R.W. WRIGHT ET AL), 20 August 1974 (20.08.74) --	1-8
A	US, A, 3777668 (R.W. COREY), 11 December 1973 (11.12.73) -- --------	1-8

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INTERNATIONAL SEARCH REPORT

Information on patent family members

01/04/95

International application No.
PCT/FI 95/00043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
SE-B- 470425	21/02/94	EP-A- 0594751	04/05/94
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		US-A- 5392900	28/02/95
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